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THE USE OF LIME AND GYPSUM ON CALIFORNIA SOILS.

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Much confusion exists in the popular mind with reference to the actual nature of lime and its use. The following brief statements are intended to clear up difficulties which exist and to reply to frequently recurring questions on the important subjects of lime and its use and gypsum and its use.

The Nature and Functions of Lime.

The term "lime," as we may employ it in the agricultural sense, includes the following materials: Burnt lime (oxide of calcium), hydrated or water-slaked lime (hydrate of calcium), ground limestone or air-slaked lime (carbonate of calcium). *Even in the agricultural sense the term lime does not include gypsum.* The latter is an entirely different substance from the three named above, as will be explained later. Speaking with the correctness of the chemist the term "lime" is applied only to burnt lime (quicklime) or calcium oxide. Just how the three materials discussed agriculturally under the name lime are to be employed and where one is to be preferred to the other, if at all, are questions which are answered below.

Before going into a detailed description of the mission or the function of lime in soils it is well to state clearly the relative values for practice of (1) the burnt, caustic, or quicklime; (2) the hydrated or water-slaked lime, and (3) the carbonate or air-slaked lime. These lime materials are largely valued for the amount of calcium oxide which they contain. Quicklime is nearly all calcium oxide. Hydrated lime or water-slaked lime contains less calcium oxide but may be looked upon in practice as nearly equivalent ton for ton to the quicklime. Air-slaked lime (like the ground limestone) or carbonate of lime contains only a little more than half the amount of calcium oxide that the quicklime does and therefore two tons of it should be employed if it is used in place of the caustic form. The relative money values can be determined at any time from the foregoing explanation of relationship between the different lime materials. It must also be remembered in that connection, however, that the cost of handling larger quantities and additional freight rates involved must always be taken into consideration in calculating the actual and relative cost of the different materials. The following is a consideration of the function of lime materials in soils:

1. Lime materials have the power of shrinking clay and making it more pervious to water and air, by making a large number of crumbs from large sticky masses. Therefore, lime makes clays and clay adobe soils looser, prevents their packing, baking and cracking, makes plowing

and cultivating easier, and, in general, makes the soil, physically, a healthier medium for plant growth.

2. Lime materials (as above described) serve as a source of the element calcium to plants. Calcium is one of the ten essential chemical elements in plant growth.

3. Lime materials make "sour" soils "sweet." Speaking correctly, they change an acid soil condition to a slightly alkaline one. Acidity of soils is very detrimental to the growth of many agricultural crops. A slightly alkaline condition is ideal for them.

4. Lime materials are necessary for useful and beneficial bacteria and other microorganisms of the soil. It furnishes these the element calcium, which is as essential to them as to the higher plants. It promotes a slightly alkaline condition which is ideal for their development. By its physical effects lime produces good air and moisture conditions for bacteria as above described.

5. Lime materials promote the normal decay of soil organic matter through their effects on the agencies of decay above described. The normal decay of organic matter in soil prevents accumulation of poisonous materials in soils which are detrimental to plant growth.

6. Lime will not neutralize sodium carbonate or black alkali.

The Nature and Function of Gypsum.

Gypsum is the sulfate of calcium and therefore is not the same as "lime" nor the same as any of the three forms of the latter above described. The only thing which gypsum has in common with the three lime materials named, from the point of view of chemical composition, is that it, like the others, contains the element calcium. Let us study its functions in soils.

1. Gypsum exerts a similar effect to that of lime on the clay and adobe soils (see above).

2. Gypsum, like lime, serves as a source of the element calcium (see above).

3. Gypsum, like lime, stimulates the beneficial soil organisms on the roots of luguminous plants like the peas, beans, vetches, alfalfas and clovers.

4. *Gypsum does not make "sour" soil "sweet." It will not change an acid into a slightly alkaline soil as do the lime materials. Gypsum is a neutral salt (possesses no alkalinity), and therefore will not be of assistance, or act as a corrective to a "sour" or acid soil.*

5. Gypsum does not share with lime, to any appreciable extent, the good effects of the latter on soil organic matter (see above).

6. Gypsum will neutralize sodium carbonate or "black alkali."

Lime versus Gypsum.

The question comes to us so frequently as to whether "lime or gypsum" will correct a certain difficulty in soils. This confusion of two distinct types of substances has done much harm, and the reader is asked to read carefully the statements made above with respect to each in order that errors may be obviated. As above noted there are at least two very important functions which lime performs in the soil which gypsum can not perform. If soils need correction for acidity, or it is desired to promote normal decay of organic matter only, the lime

materials will do and not the gypsum. Too much emphasis can not be placed on this distinction. In fact, to be on the safe side the use of lime is advised even in cases in which people with exact information might, perhaps, give the preference to gypsum. The distinct and limited uses for gypsum are below described, however, to serve as a guide.

Lime on Heavy Soils.

No determination needs to be made to inform the owner of heavy land if lime is necessary to improve its texture as above described. The decision both as to the amount to apply and as to the feasibility of applying it must be made on the basis of the cost of lime and the degree of "running together" or baking and cracking, which is characteristic of the soil. From one to two tons of the burnt lime or of the hydrated lime, or from two to four tons of the ground limestone, may be safely applied to improve the working qualities of heavy soils. Application may be made by means of one of the several types of lime spreading machines or the lime may be deposited in piles and spread with a shovel. It should be well plowed in and covered up at a time when there is sufficient moisture in the soil for the lime to act well.

The burnt lime or the hydrated lime is to be preferred to the carbonate of lime for making heavy soils lighter if the cost will allow. The first two forms act more vigorously and more quickly. Applications of lime are best made prior to fall or winter plowing or several months prior to planting. This must particularly be borne in mind if either burnt lime or hydrated lime are employed.

Lime on "Sour" or Acid Soils.

If "sour" soils are also heavy clays or clay adobes, the recommendations for the use of lime above made for heavy soils are to be followed. If sour soils are loams, silts or sands, the ground limestone is to be preferred to the other forms of lime where it is obtainable.

To test your soil for sourness or acidity proceed as follows: Mix some of the surface soil to be tested and moisten thoroughly. Mold it into a ball of wet earth about three or four inches in diameter. Break the ball in two and on one of the broken surfaces place two strips of red litmus paper previously moistened with clean boiled water. (Litmus paper, both red and blue, may be obtained in the drug stores.) Set the broken surfaces of earth together again and press tightly. Perform the same test with another ball of earth, but use blue instead of red litmus paper. Allow the balls of earth to lie undisturbed for half and hour; then open, and if the red litmus paper has turned blue no lime is needed. If it remains red, and the blue litmus paper turns red, lime is needed and should be applied as above directed. If neither the red nor the blue litmus paper should change color during half an hour or more, then the reaction of the soil is neutral and small applications of ground limestone, not to exceed one ton per acre, will be sufficient.

When and How Gypsum May be Used.

Gypsum may be used to good advantage on alfalfa fields to stimulate the growth of the plants. This is especially to be remembered in connection with alfalfa fields of several years standing in which bald spots

or bare patches are found. An application of gypsum in such cases, not to exceed 300 or 400 pounds to the acre, along with fall disking will give striking stimulation to the plants and rejuvenate the field. The reason for this is that gypsum is a stimulant to the alfalfa plant itself and to the nitrogen gathering bacteria which grow in the nodules on its roots.

If lime is very expensive, as it may be in some districts of this State, gypsum, if much cheaper, may also be used as indicated above, to lighten heavy soils. Applications varying from one half ton to one ton per acre may be used in such cases.

Another use for gypsum, which is more limited, consists in applying it to "black alkali" land to neutralize or make harmless the black alkali. *In this respect gypsum can not be replaced by lime.* The amounts to be used in such cases will depend on the amount of black alkali present in the soil. This must be determined for those interested by the Experiment Station, which should be communicated with under such circumstances.

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